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URBAN MORPHOLOGY ANALYSIS BY REMOTE SENSING AND GIS TECHNIQUE, CASE STUDY: GEORGETOWN, PENANG

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Keywords: Urban morphology, GIS, Remote sensing, urban planning, urban societies

Abstract: This paper was analysed the potential of applications of satellite remote sensing to urban planning research in urban morphology. Urban morphology is the study of the form of human settlements and the process of their formation and transformation. It is an approach in designing urban form that considers both physical and spatial components of the urban structure. The study conducted in Georgetown, Penang purposely main to identify the evolution of urban morphology and the land use expansion. In addition, Penang is well known for its heritage character, especially in the city of Georgetown with more than 200 years of urban history. Four series of temporal satellite SPOT 5 J on year 2004, 2007, 2009 and 2014 have been used in detecting an expansion of land use development aided by ERDAS IMAGINE 2014. Three types of land uses have been classified namely build-up areas, un-built and water bodies show a good accuracy with achieved above 85%. The result shows the built-up area significantly increased due to the rapid development in urban areas. Simultaneously, this study provides an understanding and strengthening a relation between urban planning and remote sensing applications in creating sustainable and resilience of the city and future societies as well.

1. INTRODUCTION

Rapid development in urban settlement contributes to the changes of environmental, economic and social activities. This transition of the metropolitan area, city, town or village from the past to the present condition describe the process of urban growth which gives impacts to the form and structure of settlements. Therefore, urban morphology become as an essential key for the urban development to identify and determine the resilience of the whole urban system that will create urban dynamic as well. The understanding of urban growth and interpretation of urban morphology can be a key challenge to the rapid urbanization of the settlements.

Besides that, urban morphology analysis can help to identify the transformation of the urban form development and the evolutionary of urban form and structure (Cheng, 2011). Urban morphology plays fundamental role in the resilience of the urban system and enhances the urban growth of the specific settlement. It can represent as a tool to control the development activity and provide opportunities and constraints for city-building processes, such as land subdivision, infrastructure development, or building construction. The criteria in the evolutionary process of development at the particular city such as plots, blocks, street layout, buildings, urban material and open spaces are considered as part of the history. Therefore, this transformation affecting urban morphology includes economic, technological globalization, environmental and climate impact, demographic change and household preferences (Bentley and Butina 1990; Gillen, 2006).

The urban morphology analysis aided by using geographic information system (GIS) and remote sensing technique. These techniques can reveal the relationships of pattern, trend, form and structure of urban settlements. It will help to investigate the past and present patterns and trends of urban growth. Both techniques can provide a useful and direct measure of the physical form and morphology of urban land cover that is very useful in delineating the extent of individual urban settlements and in generating magnitude of size estimates for settlement systems (Batty and Longley, 1994). Moreover, the developments of these techniques have led to significant improvements in its capability for decision-making process in selected major areas.

2. INTERRELATION OF URBAN MORPHOLOGY, GIS AND REMOTE SENSING

Urban morphology is an approach in designing urban form that considers both physical and spatial components of the urban structure (Paul, 2008). In addition, urban morphology is the study of the city as a human habitat. It analyses a city's evolution from its formative years to current transformations which identifying and dissecting its various components. Therefore, buildings, gardens, parks, streets and monuments consider as main elements of morphology

analysis. However, these elements consider as organisms that constantly used and transformed through time. The urban morphology analysis could be a yardstick to understand and to design the sustainable urban form and spatial structure in order to produce dynamic urban settlements. As can be seen, the symbiotic and interrelation of the urban form towards economic, environment and social activities, will provide systematic interactions and resilience to the urban settlements.

Using GIS and remote sensing technique are the methods in analyzing the evolution of urban morphology. GIS is a computer-based information system used to digitally represent and analyse the geospatial data or geographic data. GIS technique enables to have a better understanding and evaluate data in many major areas such as environmental and natural resource management, facilities management, street network planning and engineering and information system. Therefore, GIS is most widely used technologies application that is used in the whole world.

Besides that, remote sensing also can detect the transformation of urban morphology when the transitions of land cover from one type to another or when the intensity of the land use or even the material composition changes. Moreover, urban morphology can change over time as the new urban fabric is added and as the existing fabric is internally modified. For example, new buildings replace old ones, plots are amalgamated or subdivided, street layout is modified and more. The changes of internal components are major concerns that represent the interrelation of physical evolution, such as economic, cultural and political dimensions that associated with the urban dynamics (Rashed et. al., 2005).

Urban morphology analysis requires multi-temporal data sets that covering the whole urban areas across a long period. This analysis can summarize the changes and trends of urban form and urban spatial structure. Therefore, morphology analysis can investigate the relationship between the land covers changes and population density from past and present year in order to identify the urban growth rate either decrease or increased, the population growth rate or the built up density.

Thus, this research is to identify the evolution and changes of urban morphology in urban settlements within particular years. Remote sensing and GIS is now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the analysis of earth's system function patterning and change at local, regional and even global scales. By using this method, the transition of urban settlements in terms of urban form and spatial structure can be analysed and it will help to forecast future development that suitable and create sustainable and resilience for urban growth.

3. STUDY AREA

The study is located in Georgetown, Penang. The history of Georgetown is located in the state of Penang. The state of Penang comprises of Penang Island and George Town is the heart of the metropolitan area which is the second largest urban conurbation in Malaysia. The city of Georgetown was established in 1786 by the British and it is the first British port town along the Straits of Malacca. Georgetown is listed as a UNESCO World Cultural Heritage Site in 2008 as "Historic Cities of the Straits of Malacca". It was the first British port town which has a unique architectural and cultural townscape without parallel anywhere in East and Southeast. The city has more than 200 years of urban history. Therefore, the urban morphology of Georgetown will be analysed to understand the trends and patterns of urban form and the expansion of urban growth.

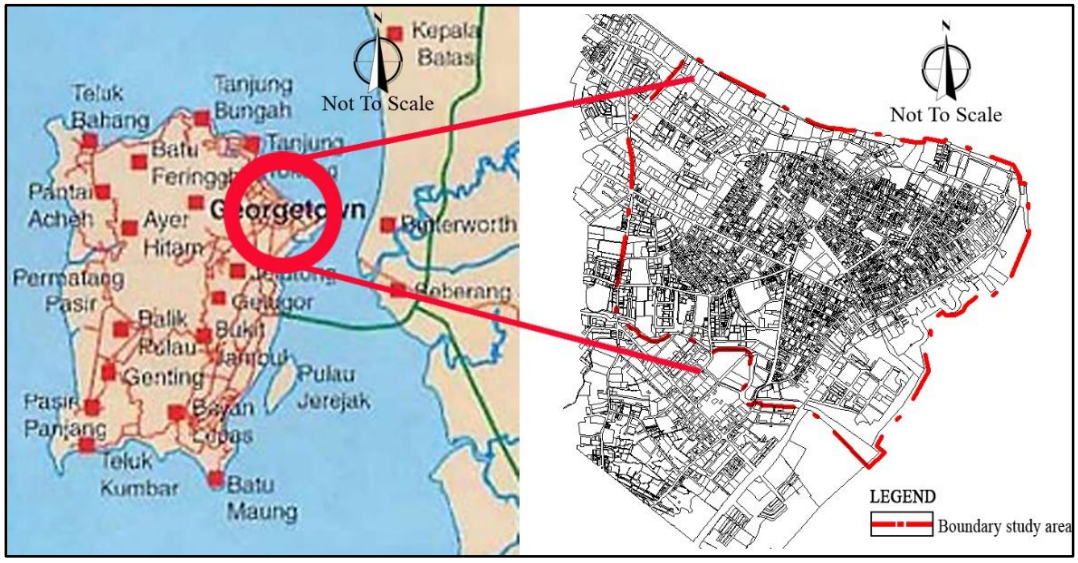

Figure 1:
Key Plan (left) and Location Plan (right) of the study area.

4. MATERIALS AND METHOD

4.1 Data and Ancillary Information

The data have been collected from primary and secondary data sources (Table 1). In this study, land use map of Georgetown, satellite images from Spot 5 J and Draft special area plan of Georgetown are used in this study. For Spot 5 J, there are four satellite images (nominally 2004, 2007, 2009, and 2014) are used in order to identify land-cover changes in the study area.

Table 1:
Materials and data used in this study.

Data Types	Year	Provider	Process	Output
Maps				
Land use map of Georgetown	2011	Town and Country Planning Department (TCPD)	Digitize, coordinates	Map of Georgetown 2011
Satellite Images				
Spot 5 J	2004,2007,2009,2014	Malaysian Remote Sensing Agency (MRSA)	Geometric correction, Enhancement, Classification	Land use and land cover map 2004,2007,2009 & 2014
Others				
Draft Special Area Plan Georgetown	2011	Town and Country Planning Department (TCPD) Pulau Pinang		
Google Map	2014	Website Google		

4.2 Methods

All the digital form of data is readily used in data processing in Digital Image Processing System and Geographic Information System. ERDAS IMAGINE 2014 are the main software that used to analyse the land cover changes, while MapInfo Professional 12.0 is the Geographic Information System used to generate various thematic layers consisting of Georgetown administrative boundaries, roads, land use, and boundary map in Georgetown map 2011.

The change detection technique is used in order to analyse the differences of the urban change by observing it at different times or interval years (2004, 2007, 2009 and 2014). Therefore, in this research, several satellite images from Spot 5 J satellite are used to detect the changes in the urban area. This technique involves the application of multi-temporal data sets to quantitatively analyse the temporal effects.

5. RESULTS AND DISCUSSION

In order to analyse the morphology and the expansion development in Georgetown City, four satellite images from the year 2004, 2007, 2009 and 2014 are classified using supervised classification aided by ERDAS IMAGINE 2014. The image classification is assigned with three different classes which build up area, unbuilt-up area and water bodies. The result of classification shows that three types of land use of the built-up, unbuilt-up area and water bodies are successfully classified. The assessment of the classification was carried out based on the classified image in each processing. Table 2 shows the accuracy assessment obtained from the classification process done to every each satellite imagery. An overall classification accuracy of over 85% has been achieved during image processing.

Table 2:
Accuracy Assessment for land use classification for the images

Satellite Images	Year	Accuracy (%)	Kappa Statistic
Spot 5 J	2004	95.00	0.9208
	2007	95.00	0.9200
	2009	93.68	0.8998
	2014	98.67	0.9776

Accuracy assessment is important in land use change detection technique which lead to determine the quality of the information based on the remotely sensed data. Moreover, this assessment reflects the degree of correctness of a map or classification.

5.1 Land Use Change Detection

After accuracy assessment successfully done, the change detection technique can be carried out to analyse the changes of land cover in Georgetown city. The result of the analysis due to the expansion of land use were highlighted through increases of percent in built-up and unbuilt-up area. İt clearly shows that built-up area increases from 70.29% in 2004 to 78.45% in 2014. Meanwhile, for unbuilt-up area decrease of 15.3% (2004) to 8.2% (2014).

From the table, the average rate per year of built-up area increase to 11.8 acres per year with 0.7% within 11 year period. Due to the rapid urbanization occurred in Penang, most of the unbuilt up area became built up area to accommodate the demand capacity for future populations. İt shows that Georgetown city was transformed to be one of the develop city in Malaysia.

Table 3
Comparison of area between land use class from year 2004 until year 2014

Types of Land Use	Year								Average Rate of Change (2004-2014)	
	2004		2007		2009		2014			
	Area (acre)	%	Area (acre)	%	Area (acre)	%	Area (acre)	%	Acre/ yr	%/ yr
Built-up Area	1119.0	70.3	1201.0	75.4	1219.0	76.6	1249.0	78.5	11.8	0.7
Unbuilt-up Area	243.4	15.3	166.0	10.4	153.0	9.6	130.8	8.2	10.2	0.6
Water Bodies	229.6	14.4	225.0	14.1	220.0	13.8	212.2	13.3	1.6	0.1

The result clearly shows that the urban development significantly increased. The expansion urban area mostly towards the Malacca Strait, where the Georgetown history as first British port cities. It shows that the town expands inwards and the series of reclamation with the extending towards Weld Quay as the new waterfront. Due to rapid changes faced by Georgetown, unbuilt-up area decreased and it lead to the built up area increased with the increasing intervention from high rise construction and new developments within the historic urban fabric. Hence, it gives some transformation and evolution in urban morphology of the city (Shuhana et. al., 2012).

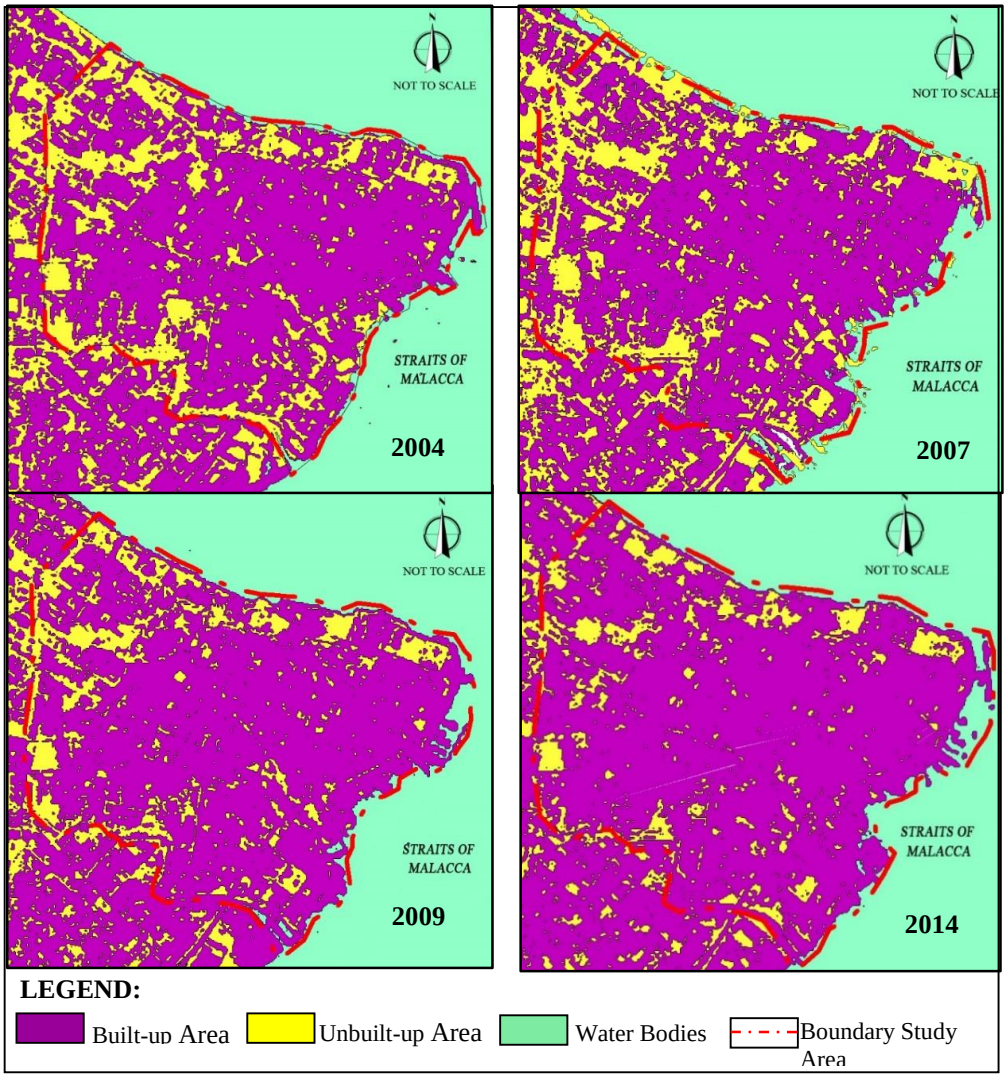

Figure 2:
Temporal land use classification in study area obtained from SPOT 5 J imageries

6. CONCLUSION

In this study, it shows that Georgetown city faced rapid development within 11 years from 2004 until 2014. Thus, it provides a basic understanding on how the city faced the evolution of development in terms of urban forms and urban spatial structure. With this knowledge, it can show how important of the city's history in designing and development to become one of the most resilient and sustainable city. In the recent years, the challenge facing most of the urban areas is how to accommodate future population and development growth in a sustainable manner. The Urban morphology study provides important knowledge to the planner in order to develop any area in a city or even for fringe belt. Lack of interest and awareness of history among the planner and others prevents developing the settlements into a systematic urban dynamic. Hence, the responsibility for the built environment is not taken seriously towards realization of sustainable urban development. Therefore, urban planners need information that will be enabled to respond to the expectations and needs of the urban growth. At this point, it can help to forecast future model of urban settlements.

Moreover, the urban morphology study can help in design control through policy. Due to deficiency in policy for design control, urban morphology study can be an important issue and can be taken as consideration in developing a method for expressing detailed design policies (Hall, 1997). Besides that, cultural diversity in Georgetown has a great contribution towards the morphology of the urban area. By having multi-culture, the government could play a role in implementing the cultural policies which can be as a benchmark in produce great urban transformation (Pereira & Nofre, 2011). Thus, the local and international tourist will understand the morphology of different culture that came to Georgetown with different background of ethnicity which established from ancient year. Hence, the guidelines and

policies should take seriously by all parties such as have local authorities, Federal and State governments, Department of Museums and Antiquity, heritage trusts and other professional bodies.

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REFERENCES

References from Journals:

Batty, M., & Longley, P.A., 1994.Fractal Cities: Geometry of Form and Funtion. Academic Press, London.

Bentley, I. & Butina, G., 1990, in Gleave, S. [ed.], Urban design, *Architects Journal*, October 24, v.192, no.17, pp.61-71.

Cheng, J., 2011. Exploring urban morphology using multi-temporal urban growth data: a case study of Wuhan, China. *Asian Geographer*, *28*(2), 85–103.

Gillen, M., 2006. The challenge of attaining a sustainable urban morphology for South East Queensland. Planning Practice and Research, 21(3), 291–308.

Hall, a. C., 1997. Dealing with incremental change: An application of urban morphology to design control. Journal of Urban Design, 2(3), 221–239.

Markham, B. L., & Helder, D. L., 2012. Forty-year calibrated record of earth-reflected radiance from Landsat: A review. Remote Sensing of Environment, 122, 30–40.

Moudon, A.V., 1997. Urban Morphology as An Emerging Interdisciplinary Field. International Seminar on Urban Form, 1, 3-10.

Norzailawati, M.N, Alias Abdullah & Mohd Nasrul Hanis Manzahari., 2013. Land cover change detection analysis on urban green area loss using GIS and remote sensing techniques.Malaysian Institute of Planner, MIP Journal, PMJ13 (03-13), Vol 11-2013, pp125-139.ISBN1675-6215

Pereira, P & Nofre, J., 2011. Rebuilding urban morphology : new centralities and urban inequalities in Southern European cities, 655–684.

Rashed, T.,Weeks, J. R., Stow, D., & Fugate, D., 2005. Measuring Temporal Compositions Of Urban Morphology Through Spectral Mixture Analysis : Toward A Soft Approach To Change Analysis.

Shuhana,S., Ahamd, B.S, & Rohayah, C.A., 2012. Urban Landscape Factors That Influenced the Character of George Town, Penang Unesco World Heritage Site. *Procedia - Social and Behavioral Sciences*, *50*(July), 238–253.

References from Other Literature:

JPBD., 2007. Structure Plan Pulau Pinang 2020. Jabatan Perancang Bandar & Desa Pulau Pinang.

JPBD., 2011. Draft Special Area Plan Georgetown. Jabatan Perancang Bandar & Desa Pulau Pinang.

References from websites:

Paul, S., & Congress, J., 2008. QUT Digital Repository : Presenting The Past : The Impact Of Urban Morphology In Shaping The Form Of The City. Retrieved 5 March 2014 from http://eprints.qut.edu.au